HOLLOW SECTION AND A PROCESS FOR ITS MANUFACTURE

BACKGROUND OF THE INVENTION

[0001] The invention relates to a hollow section or similar workpiece having a hollow space delimited by walls featuring end lengths which together form corner regions. In particular, the invention relates to a hollow section made of a metal alloy. The invention further relates to a process for manufacturing the hollow section.

[0002] According to the state of the art, tube-shaped or hollow-section-like deformation elements are employed to accommodate the energy of impact acting on them from the front end. The absorption of the energy of impact takes place by the section walls folding uniformly when the deformation element is crushed. Thus, for example, CH-A 691 721 describes a vehicle with a bumper which is attached to longitudinal beams via deformation elements. The deformation elements comprise multi-chamber hollow sections that have at least one longitudinal internal strut. A part of the energy of impact is absorbed by bellow-like folding as the deformation element is crushed in the longitudinal direction of the section.

[0003] Such deformation elements should exhibit the maximum possible specific absorption of energy i.e. as much energy as possible per unit mass should be absorbed. Only then is it possible to meet the requirements for the lightest and simultaneously safe vehicles – i.e. vehicles fitted with energy-absorbing structures.

[0004] German reference DE 35 32 499 C1 describes a process and device for hydraulic expansion of a length of tube by means of a plug-like probe that can be inserted into the tube and which, because of sealing rings that are spaced apart, forms

a ring-shaped space along with the length of tube that is to be expanded. This space is filled with a compressive medium for expansion of the tube length. Each of the sealing rings is situated in the probe in a ring-shaped groove which is U-shaped in cross-section and initially, on insertion of the probe into the tube, has an outer diameter that corresponds at most to the outer diameter of the probe. Before the expansion process begins, a compressive medium is applied to them in order to seal off the ring-shaped gap formed between the probe and the tube. The compressive medium is fed to the grooves by means of a medium feed-line with connecting line attached. The supply of compressive medium to the ring-shaped space takes place exclusively via at least one of the grooves and is channeled through a sealing ring serving as a valve body which closes off an opening between the groove and the ring-shaped space until it has achieved its sealing property as a result of elastic expansion. At its edge neighboring the ring-shaped space, that groove is provided with at least one sloping cut. If the pressure in the ring-shaped space between the two seals is increased, the wall of the tube begins to expand in this region.

[0005] When calibrating, corners or sudden changes in wall thickness cause non-uniform deformation. Also, walls of different thickness expand non-uniformly under high internal pressure forming. If two such walls begin from a corner, then both walls are pressed onto the shaping tool as a result of the high internal pressure. The thicker wall remains there while the thinner wall – as a result of the smaller moment of resistance – is drawn into the corner. This leads to a thinning of the thinner wall towards the corner region.

[0006] In order to counter the risk of cracking due to weakening of the component, and in order to achieve a constant wall thickness for thermal connections, German reference DE 198 51 326 C1 proposes - on the thicker of the two walls, viz., end wall and side wall, forming the corner - an end length of thinner wall extending from the corner to the thinner wall, the thickness of which

corresponds approximately to that of the thicker wall. The thickness of the end length is constant and, at an inner step, this changes over to the thinner region of the thin wall. Foreseen in another version is a corner that becomes thinner in cross-section from the thicker wall, or an end length is curved in cross-section between the thicker wall and the thinner wall and then preferably features an arc-shaped inner contour of that cross-section or a parabola-shaped inner contour.

SUMMARY OF THE INVENTION

[0007] In view of the above, the object of the present invention is to provide a hollow section of the kind mentioned above, which exhibits a higher specific absorption of energy than a conventional deformation element. Furthermore, the resistance to rupture of such hollow sections during forming and in use should be improved.

[0008] Pursuant to this object, and others which will become apparent hereafter, one aspect of the present invention resides in the thickness of the corner part of the wall joining up to the corner region being reduced continuously to a smaller thickness i.e. the cross-section of the wall decreases without steps - which would form potential weak points. Two forms of design have proven to be particularly favorable in this respect; in one case the thickness of the end part of the wall of the hollow section is kept constant over a length starting from the corner and begins to diminish continuously at the foot of this end length; in the other case the thickness of the wall diminishes constantly from one corner region to the other corner region of the hollow section.

[0009] According to another feature of the invention, the length of the above mentioned end part of the wall – in particular a section side wall – amounts to about one third to one quarter of the wall length.

[0010] Preferred is that a length of wall that becomes thicker is joined up to - and runs counter to - the end length of wall which narrows in cross-section from a corner region of the hollow section. This wall consists, therefore, of two parts that become thicker running counter to each other; the transition between these has no steps and offers thereby the above mentioned advantages. Likewise, the other shape can also be employed if a wall section, featuring an end length of constant thickness that connects up with a transverse wall at one end and tapers to a smaller thickness in cross-section in a continuous manner from the other end, is extended further by an integral wall section in the form of a wall which in cross-section runs counter to the other transverse wall. The other transverse wall may feature or be without an end length of constant thickness.

[0011] In a further version of the hollow section according to the invention the outer wall of the hollow section exhibits a middle part of constant thickness, in each case between two end lengths of diminishing thickness running counter to each other;. These end lengths therefore flank the middle part and together with the middle part produce an outer face on a common plane.

[0012] Also within the scope of the invention is that two facing outer walls of the hollow section – preferably running parallel to each other – are joined on the inside by at least one integral inner wall. Thereby the outer walls along with the inner walls delimit a plurality of hollow spaces and the walls of each section space exhibit a middle length of constant thickness and increasing thickness in both of its end lengths.

[0013] According to a further feature, the outer walls of the hollow section exhibit a rectangular cross-section, the center of which being the region where two inner walls cross each other. The cross-sectional length of the middle part should thereby be about double the cross-sectional length of the integral end part.

[0014] Usefully, the wall thickness of the end part of the outer wall near the corner region increases in a continuous manner, whereby a middle plane of the wall forms a plane of symmetry.

[0015] It has been found favorable for the maximum wall thickness – or the average wall thickness – of the end length of the section wall to be at least 5%, preferably at least 15% , and in particular at least 20% greater than the wall thickness of the length of section wall neighboring the end length of section wall, or the maximum or average wall thickness of the end length of section wall should be at most 200%, preferably at most 100%, in particular at most 60% greater than the minimum wall thickness of the length of section wall neighboring the end length of section wall.

[0016] Finally, according to another feature of the invention, the thickness of the length of section wall neighboring the end length of section wall is uniform or constant. Also, the outer face of the section wall should be flat and its inner section wall face in the end lengths of section wall should exhibit a slope with respect to the outer face which increases the wall thickness.

[0017] In each case the result is a new type of hollow section that achieves the set objective in an attractive manner.

[0018] Of particular significance for the invention is that the above mentioned hollow section should be shape-formed by means of a high internal pressure in the section interior using a medium capable of flow viz., so-called high internal pressure forming (HIP-Process). With this method the hollow section is expanded outwards by internal pressure. Further, the hollow section may be subjected to compression by at least one tool which acts on the workpiece at the end. This way the workpiece may be widened, compressed or expanded.

[0019] For a more complete understanding of the hollow section and a process for its manufacture of the present invention, reference is made to the

following detailed description and accompanying drawings in which the presently preferred embodiments of the invention are illustrated by way of example. That the invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, it is expressly understood that the drawings are for purposes of illustration and description only, and are not intended as a definition of the limits of the invention. Throughout the following description and drawings, identical reference numbers refer to the same component throughout the several views.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Further advantages, features and details of the invention are revealed in the following description of preferred exemplified embodiments and with the aid of the drawing which shows in:

[0021] Fig. 1: a perspective view of a single-chamber hollow section of approximately rectangular cross-section;

[0022] Fig. 2: enlarged front elevation of the section shown in figure 1;

[0023] Fig. 3: front elevation of a multi-chamber hollow section; and

[0024] Fig. 4: cross-section through a further single-chamber hollow section.

DETAILED DESCRIPTION OF THE INVENTION

[0025] In so-called high internal pressure forming (HIP) a hollow section 10 made of an aluminum alloy and manufactured by extrusion is expanded by means of pressure created in its hollow chamber 12. This single-chamber hollow section10 of approximately rectangular cross-section of breadth b and height h features two transverse walls 14 as base wall or end wall and side walls 16 connecting the

transverse walls 14. The section's straight outer faces 15, 17 delimit rounded section corners 30 which run parallel to the longitudinal axis A of the section.

[0026] The inner faces 15_i, 17_i of the walls 14, 16 – of outer length b and h resp. – have, with respect to the neighboring outer face 15, 17 a parallel middle part which delimits a wall length 14_m, 16_m of constant thickness e, e_i and length a, c. Connecting up to the middle wall length 14_m, 16_m at each end is an end part 14_e, 16_e of uniformly increasing thickness f, f_1. Thereby, the wall thickness e, e_1, f, f_1 are measured perpendicular to the wall middle face E, E_1 in question.

[0027] Fig. 3 shows a multi-chamber section 11 of breadth b and height h with four chambers 12; connecting up with the inner faces 15_i, 17_i of transverse walls 14 and side walls 16 – in each case in the middle – are inner walls 26, 28, which cross in the center Q of the hollow section and in cross-section form a central crossing region 27. Both crossing beams of this symmetrical cross form the inner walls of the four section chambers or spaces 12, their outer limit being given by the outer walls 14, 16.

[0028] The outer walls formed by the transverse walls 14 and the side walls 16 feature generally flat faces 15, 17 between the corners 30 of the section. In this design each of the wall lengths delimiting the section chambers 12 is, as described in Fig. 2, made up of the middle parts 14_m, 16_m – here of length a_1 or c_1 – and the end parts 14_e, 1_e. Likewise, the inner section walls or inner walls 26, 28 – corresponding to the outer walls 14, 16 described above – are divided into section wall middle lengths 26_m, 28_m of length n, n_1 and constant thickness g, g_1, and end lengths 26_e, 28_e of increasing thickness i, i1. For the latter a middle plane M, M1 forms a plane of symmetry i.e. the end lengths 26_e, 28_e broaden out conically until meeting up with the integral outer walls 14, 16.

[0029] The end lengths 26_e, 28_e of the inner section walls 26, 28 close to the above mentioned center Q form the central crossing or nodal region 27. The other

end lengths 26_e, 28_e of the inner section walls 26, 28 represent outer nodal regions 32, 34 at the intersection with the outer section walls 14, 16.

[0030] The hollow section 10_a in Fig. 4 is likewise a single chamber section and exhibits an upper transverse wall 18 or end wall of constant thickness e_2 of 3 ± 0.2 mm which lies opposite – an outer distance q here of approx. 75 mm from – a parallel base wall 14 of smaller constant thickness e_3. Both are integrally joined to a side wall 20 running perpendicular to both walls 18, 14. The overall length h_1 of this side wall 20, which features an extension rib 19, is here approx. 95 mm. For reasons of clarity a co-ordinate cross X, Y lying parallel to the wall 18 and the side wall 20 is shown in the drawing.

[0031] The length t, approx. 51 mm, of the base wall 14 is slightly smaller than the length t_1 , approx. 58 mm, of the wall 18, with the result that the second side wall 22 of the hollow section 10_a is inclined at an angle w of approx. 85° to the plane of the shorter base wall 14. The end length 22_e of the sloping section wall 22, which meets up with the wall 18 forms an upper section corner 30, is of length g_1 = 15 mm and thickness y = 2.0 ± 0.2 mm. Joining up at the bottom end point 24 of the end of length 22_e is an inner face 23_i which is inclined to the outer face 23 of side wall 22 and defines the thickness z = 2.0 ± 0.2 mm in the lower corner 30_t of the section 10_a.

[0032] The inner face 21_i of the left wall 20 in the drawing is as a whole, from its top region of thickness y_1 neighboring the wall 18 to its lower section corner 30_t, inclined with respect to the outer face 21 of this side wall 20. At the lower end, the thickness z_1 of the side wall 20 likewise measures 2.0 ± 0.2 mm.

[0033] The transition between the end length 22_e of the side wall 22 and the end wall 18 is likewise rounded as is the transition between the end wall 18 and the other side wall 20.

[0034] The different cross-sectional shape of the left side wall 20 in Fig. 4 on the one hand and the right side wall 22 featuring the end length 22_e on the other

hand is shown by way of example in a hollow section 10_a. It is, however, also possible to select one or the other shape for both facing walls 20, 22 of a hollow section.

[0035] Not shown is another shape of hollow section in which the cross-sectional shape of the side wall 20 or 22 runs counterwise in an extended part of the side wall, which again increases the smaller thickness z continuously to a greater thick-ness y_1. In this design it is also possible to include a second end length of constant thickness y.

[0036] Although the present invention has been described in relation to particular embodiments thereof, many other variations and modifications and other uses will become apparent to those skilled in the art. It is preferred, therefore, that the present invention be limited not by the specific disclosure herein, but only by the appended claims.